Revista Ciência Agronômica, v. 54, e20218267, 2023
Centro de Ciências Agrárias - Universidade Federal do Ceará, Fortaleza, CE
www.ccarevista.ufc.br

Scientific Article
ISSN 1806-6690

Optimal plot size in wheat with comparison of three methods[1]

Tamanho ótimo de parcela em trigo com comparação de três métodos

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ABSTRACT - The objectives of this study were to determine the optimal plot size (Xo) to evaluate the fresh matter productivity of wheat (*Triticum aestivum* L.) and check whether Xo differs between three determination methods. Five uniformity trials were carried out. Trials 1 and 2 were carried out, respectively, with the cultivars TBIO Sossego and TBIO Toruk, both sown on August 3, 2018. Trials 3, 4 and 5 were carried out with the cultivar TBIO Audaz, sown, respectively, on June 7, 2019, June 27, 2019 and July 18, 2019. Fresh matter productivity was evaluated in 540 basic experimental units (BEU) of 1 m × 1 m (108 BEU per trial). The BEU was formed by five rows of 1.0 m in length, spaced 0.20 m apart, totaling 1.0 m^2. The optimal plot size was determined using the methods of modified maximum curvature, linear response and plateau model and quadratic response and plateau model. The optimal plot size differs between the methods and decreases in the following order: quadratic response and plateau model (15.78 m^2), linear response and plateau model (7.11 m^2) and modified maximum curvature (2.56 m^2). The optimal plot size to evaluate the fresh matter productivity of wheat is 7.11 m^2 and the experimental precision stabilizes from this size on.

Key words: *Triticum aestivum* L. Uniformity trial. Modified maximum curvature. Linear response and plateau model. Quadratic response and plateau model.

RESUMO - Os objetivos deste trabalho foram determinar o tamanho ótimo de parcela (Xo) para avaliar a produtividade de matéria fresca de trigo (*Triticum aestivum* L.) e verificar se Xo difere entre três métodos de determinação. Foram conduzidos cinco ensaios de uniformidade. Os ensaios 1 e 2 foram conduzidos, respectivamente, com as cultivares TBIO Sossego e TBIO Toruk, ambas semeadas em 03 de agosto de 2018. Os ensaios 3, 4 e 5 foram conduzidos com a cultivar TBIO Audaz semeada, respectivamente, em 07 de junho de 2019, 27 de junho de 2019 e 18 de julho de 2019. Foi avaliada a produtividade de matéria fresca em 540 unidades experimentais básicas (UEB) de 1 m × 1 m (108 UEB por ensaio). A UEB foi formada por cinco fileiras de 1,0 m de comprimento, espaçadas 0,20 m entre fileiras, totalizando 1,0 m^2. Foi determinado o tamanho ótimo de parcela por meio dos métodos da curvatura máxima modificado, do modelo linear de resposta com platô e do modelo quadrático de resposta com platô. O tamanho ótimo de parcela difere entre os métodos e decresce na seguinte ordem: modelo quadrático de resposta com platô (15,78 m^2), modelo linear de resposta com platô (7,11 m^2) e curvatura máxima modificado (2,56 m^2). O tamanho ótimo de parcela para avaliar a produtividade de matéria fresca de trigo é 7,11 m^2 e a precisão experimental estabiliza a partir desse tamanho.

Palavras-chave: *Triticum aestivum* L. Ensaio de uniformidade. Curvatura máxima modificado. Modelo linear de resposta com platô. Modelo quadrático de resposta com platô.

DOI: 10.5935/1806-6690.20230012
Editor-in-Chief: Profa. Charline Zaratin Alves - charline.alves@ufms.br
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Received for publication 16/11/2021; approved on 09/08/2022
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INTRODUCTION

Experiments with crops of agricultural importance such as wheat (*Triticum aestivum* L.) should be planned appropriately, prioritizing the achievement of high experimental precision (low coefficient of variation) and, consequently, reliability in inferences regarding the treatments evaluated. The experimental error, resulting from the variation between the experimental units (plots) that received the same treatment, should be minimized so that smaller differences between treatment means are identified as significant, that is, no random variations are attributed (STORCK *et al*., 2016).

Defining the optimal plot size is an important aspect in experimental planning and can contribute to minimizing experimental error. This minimization is due to the fact that the coefficient of variation decreases gradually and non-linearly with the increase in plot size. This response pattern makes it possible to use different methods of determining the optimal plot size in datasets obtained in uniformity trials (blank experiments) (STORCK *et al*., 2016).

With these datasets, it is possible to plan different plot sizes (X) by grouping adjacent basic experimental units (BEU) and estimate the coefficient of variation ($CV_{(X)}$) between the BEU. $CV_{(X)}$ values as a function of X can be related through the methods modified maximum curvature (MMC) (MEIER; LESSMAN, 1971), linear response and plateau model (LRP) (PARANAÍBA; FERREIRA; MORAIS, 2009) and quadratic response and plateau model (QRP) (PEIXOTO; FARIA; MORAIS, 2011), and make it possible to determine the optimal plot size (Xo) and the coefficient of variation in the optimal plot size (CV_{Xo}).

Comparative studies involving the MMC, LRP and QRP methods have been conducted with crops such as passion fruit (PEIXOTO; FARIA; MORAIS, 2011), maize (CARGNELUTTI FILHO *et al*., 2011), papaya (BRITO *et al*., 2012), radish (SILVA *et al*., 2012); *Acacia polyphylla* (ALVES *et al*., 2014), pineapple (LEONARDO *et al*., 2014), sunflower (SOUSA *et al*., 2015), cabbage (GUARÇONI *et al*., 2017), sweet potato (GONZÁLEZ *et al*., 2018; RODRÍGUEZ *et al*., 2018), cassava (SOUSA *et al*., 2018), bell pepper (PADRÓN; LOPES; RENEDO, 2018), cactus pear (GUIMARÃES *et al*., 2019), coffee (BRIOSCHI JUNIOR *et al*., 2020; MOREIRA *et al*., 2016); millet + slender leaf rattlebox + showy rattlebox (CARGNELUTTI FILHO *et al*., 2021a), and buckwheat (CARGNELUTTI FILHO *et al*., 2021b), highlighting different results between the methods and the importance of using more than one method to determine the optimal plot size.

The optimal plot size to evaluate the number of ears, ear weight and grain yield of wheat was determined by Henriques Neto *et al*. (2004) and Lorentz *et al*. (2007), based on different methods. In these studies, an important variable of agronomic interest, that is, the fresh matter productivity of wheat, was not contemplated. In addition, more current methods may generate different estimates of plot size.

Thus, the objectives of this study were to determine the optimal plot size (Xo) to evaluate the fresh matter productivity of wheat (*Triticum aestivum* L.) and check whether Xo differs between three methods of determination.

MATERIAL AND METHODS

Five uniformity trials (blank experiments) with wheat crop (*Triticum aestivum* L.) were conducted in an experimental area located at 29º42'S, 53º49'W and 95 m altitude. In this place, the climate is humid subtropical Cfa (ALVARES *et al*., 2013) and the soil is *Argissolo Vermelho Distrófico Arênico* (Ultisol) (SANTOS *et al*., 2018).

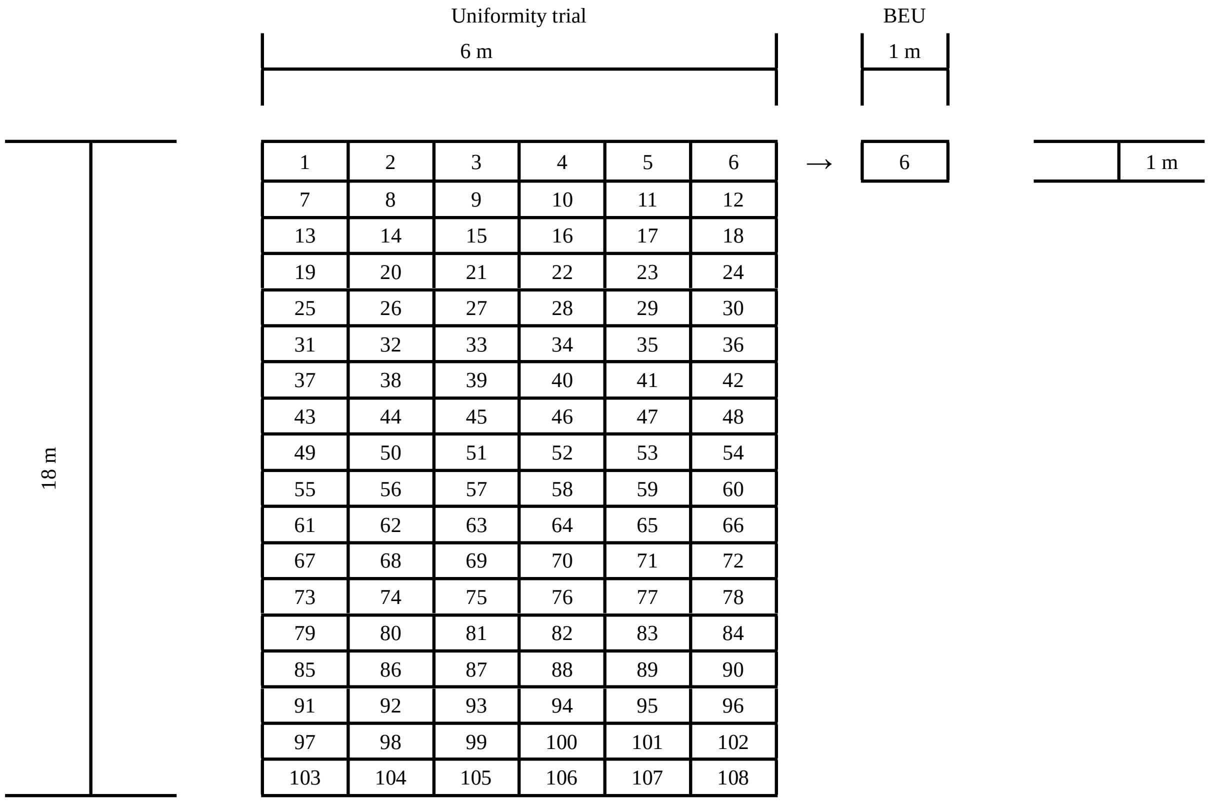
Trials 1 and 2 were conducted, respectively, with the cultivars TBIO Sossego and TBIO Toruk, both sown on August 3, 2018. Trials 3, 4 and 5 were conducted with the cultivar TBIO Audaz, sown, respectively, on June 7, 2019, June 27, 2019 and July 18, 2019. In all trials, mechanized sowing was performed in rows, spaced 0.20 m apart, at the density of 420 seeds m^{-2}. Basal fertilization consisted of 9 kg ha^{-1} of N, 36 kg ha^{-1} of P_2O_5 and 36 kg ha^{a-1} of K_2O and, subsequently, two top-dressing fertilizations of 41 kg ha^{-1} of N were performed in the development stages V3 (three expanded leaves) and V6 (six expanded leaves).

In the central area of each uniformity trial, with dimension of 20 m × 8 m (160 m^2), an area of 18 m × 6 m (108 m^2) was demarcated and divided into 108 basic experimental units (BEU) of 1 m × 1 m (1 m^2), forming a matrix of 18 rows and six columns (Figure 1). The BEU was formed by five rows of 1.0 m in length, spaced 0.20 m apart, totaling 1.0 m^2.

In each uniformity trial, fresh matter productivity was evaluated when the crop was at the dough grain development stage. For this, in each BEU of 1 m^2, the plants were cut near the soil surface and their fresh matter was weighed on a digital scale (accuracy: 1 g), to obtain the fresh matter productivity (FM, in g m^{-2}) in 540 BEU (5 trials × 108 BEU per trial).

In each uniformity trial, the FM data from the 108 BEU were used to plan plots with X_R BEU adjacent in the row and X_C BEU adjacent in the column. Plots with different sizes and/or shapes were planned as being ($X = X_R \times X_C$), that is, (1 × 1), (1 × 2), (1 × 3), (1 × 6), (2 × 1), (2 × 2), (2 × 3), (2 × 6), (3 × 1), (3 × 2), (3 × 3), (3 × 6), (6 × 1), (6 × 2), (6 × 3), (6 × 6), (9 × 1), (9 × 2), (9 × 3), (9 × 6), (18 × 1), (18 × 2) and (18 × 3). The acronyms X_R, X_C and X, mean, respectively, number of BEU adjacent in the row, number of BEU adjacent in the column, and plot size in number of BEU.

Figure 1 - Representation of an 18 m × 6 m uniformity trial and the subdivision into 108 basic experimental units (BEU) of 1 m² (1 m × 1 m)



For each plot size (X), the following parameters were determined: n - number of plots with X BEU in size (n = 108/X) and $CV_{(X)}$ - coefficient of variation (in %) between the plots of X BEU in size.

For each trial, the optimal plot size (Xo) was determined using the methods of modified maximum curvature (MMC) (MEIER; LESSMAN, 1971), linear response and plateau model (LRP) (PARANAÍBA; FERREIRA; MORAIS, 2009) and quadratic response and plateau model (QRP) (PEIXOTO; FARIA; MORAIS, 2011). In these three methods, models of the dependent variable ($CV_{(X)}$, in %) are fitted as a function of the independent variable (X, in BEU). The average $CV_{(X)}$ between the plots with the same size, but different shapes was used in the fitting of the models.

In the MMC method, parameters *a* and *b* and the coefficient of determination (R^2) of the model $CV_{(X)} = a / X^b + \varepsilon$ were estimated. Xo was determined by the expression: $Xo = \left[a^2 b^2 (2b+1)/(b+2)\right]^{1/(2b+2)}$. The coefficient of variation corresponding to the optimal plot size (CV_{Xo}) was determined by $CV_{Xo} = a / Xo^b$.

For the LRP model, two segmented lines were fitted and the parameters *a*, *b* and *p* and the coefficient of determination (R^2) were estimated. The first line $\left(CV_{(X)} = a + bX + \varepsilon\right)$ was fitted up to the point corresponding to Xo, with angular coefficient (b) different from zero. The second line $\left(CV_{(X)} = p + \varepsilon\right)$ starts from Xo and has angular coefficient equal to zero (line parallel to the abscissa), where *p* = plateau, that is, *p* corresponds to CV_{Xo}. The LRP model was as follows: $CV_{(x)} = \begin{cases} a + bX + \varepsilon \cdots if X \le Xo \\ p + \varepsilon \cdots\cdots\cdots if X > Xo \end{cases}$. In the LRP model, $Xo = (p - a)/b$ and $CV_{Xo} = a + bXo$.

For the QRP model, the fitting was performed using two segmented equations. Estimates of parameters *a*, *b*, *c* and *p* and coefficient of determination (R^2) were obtained. Up to the point of Xo, the quadratic part of the model was fitted $(CV_{(X)} = a + bX + cX^2 + \varepsilon)$. After Xo, the model turns into a zero-slope line, called plateau, whose model is described by $\left(CV_{(X)} = p + \varepsilon\right)$, where *p* = plateau, that is, *p* = CV_{Xo}. Thus, the QRP model was as follows: $CV_{(x)} = \begin{cases} a + bX + cX^2 + \varepsilon \cdots if X \le Xo \\ p + \varepsilon \cdots\cdots\cdots\cdots\cdots if X > Xo \end{cases}$. In the QRP model, $Xo = -b/2c$ and $CV_{Xo} = a - b^2/4c$. In the LRP and QRP models, the point of union between the two segments corresponds to Xo in the abscissa and CV_{Xo} in the ordinate. In the three models (MMC, LRP and QRP), ε is the residual or random error.

For the five uniformity trials, fresh matter productivity (FM, g m^{-2}), the coefficient of variation of the trial (CV, %) and the estimates of the coefficient of determination (R^2), optimal plot size (Xo) and the coefficient of variation in the optimal plot size (CV_{Xo}) were obtained for the MMC, LRP and QRP methods. For the estimates of R^2, Xo and CV_{Xo} of the MMC, LRP and QRP methods, normality was checked using the Kolmogorov-Smirnov test. The comparisons of the means of the estimates of R^2, Xo and CV_{Xo} between the methods (MMC *versus* LRP, MMC *versus* QRP and LRP *versus* QRP), regardless of cultivar and sowing date (n = 5 uniformity trials), were performed by Student's t-test (one-tailed), for dependent samples, at 5% significance level. The results of these comparisons were represented by letters next to the means. Statistical analyses were performed with the Microsoft Office Excel® application and R software (R DEVELOPMENT CORE TEAM, 2021).

RESULTS AND DISCUSSION

Fresh matter productivity ranged from 959 g m^{-2} (cultivar TBIO Audaz, sowing on 06/27/2019) to 2076 g m^{-2} (cultivar TBIO Sossego, sowing on 08/03/2018), with a mean of 1469 g m^{-2} among the three cultivars, which is equivalent to 14.69 Mg ha^{-1} (Table 1). Therefore, these cultivars provide an important fresh matter productivity when compared to the mean of accumulated fresh biomass of 20.495 Mg ha^{-1}, obtained with the wheat cultivar BRS Umbu, in three cutting systems (no cut, one cut and two cuts) (CARLETTO *et al*., 2020).

Among the five trials, the coefficients of variation ranged between 13.73% (cultivar TBIO Sossego, sowing on 08/03/2018) and 19.59% (cultivar TBIO Audaz, sowing on 06/27/2019), with a mean of 17.10%. Taking as reference the classification ranges of the coefficients of variation established by Pimentel-Gomes (2009) for field agricultural tests, all CVs are within the class of medium experimental precision (CV between 10% and 20%)

Table 1 - Fresh matter productivity (FM, in g m^{-2}), coefficient of variation (CV, in %), estimates of parameters *a*, *b* and *c*, coefficient of determination (R^2), optimal plot size (Xo, in m^2) and the coefficient of variation in optimal plot size (CV_{Xo}, in %), as a function of the methods of modified maximum curvature (MMC), linear response and plateau model (LRP) and quadratic response and plateau model (QRP), obtained from the fresh matter productivity of wheat (*Triticum aestivum* L.) cultivars, evaluated on different sowing dates

Trial[1]	Cultivar	Sowing	FM (g m^{-2})	CV (%)	a	b	c	R^2	Xo (m^2)	CV_{Xo} (%)
					MMC					
1	TBIO Sossego	08/03/2018	2076	13.73	13.073	0.128	-	0.85	1.25	12.70
2	TBIO Toruk	08/03/2018	1656	18.83	18.552	0.165	-	0.80	2.12	16.39
3	TBIO Audaz	06/07/2019	1501	14.29	14.204	0.237	-	0.99	2.26	11.71
4	TBIO Audaz	06/27/2019	959	19.59	20.192	0.334	-	0.98	3.69	13.05
5	TBIO Audaz	07/18/2019	1153	19.05	19.074	0.323	-	0.90	3.47	12.77
KS[2]								0.96	0.97	0.53
Mean			1469	17.10				0.90 a	2.56 c	13.32 a
					LRP					
1	TBIO Sossego	08/03/2018	2076	13.73	13.844	-0.756	-	0.86	6.19	9.17
2	TBIO Toruk	08/03/2018	1656	18.83	19.389	-1.147	-	0.77	6.73	11.68
3	TBIO Audaz	06/07/2019	1501	14.29	14.452	-0.973	-	0.93	7.43	7.22
4	TBIO Audaz	06/27/2019	959	19.59	19.868	-1.533	-	0.90	8.02	7.58
5	TBIO Audaz	07/18/2019	1153	19.05	18.967	-1.561	-	0.76	7.20	7.72
KS[2]								0.97	1.00	0.77
Mean			1469	17.10				0.84 b	7.11 b	8.67 b
					QRP					
1	TBIO Sossego	08/03/2018	2076	13.73	14.813	-1.451	0.094	0.89	7.76	9.19
2	TBIO Toruk	08/03/2018	1656	18.83	19.177	-1.201	0.046	0.80	13.13	11.29
3	TBIO Audaz	06/07/2019	1501	14.29	14.511	-1.128	0.042	0.96	13.46	6.92
4	TBIO Audaz	06/27/2019	959	19.59	19.403	-1.512	0.045	0.94	16.93	6.60
5	TBIO Audaz	07/18/2019	1153	19.05	16.722	-0.822	0.015	0.83	27.60	5.37
KS[2]								0.99	0.94	0.89
Mean			1469	17.10				0.88 a	15.78 a	7.87 b

[1] Each uniformity trial with size of 18 m × 6 m (108 m^2) was divided into 108 BEU of 1 m × 1 m (1 m^2), forming a matrix of 18 rows and six columns. Means of R^2, Xo and CV_{Xo} not followed by the same lowercase letter in the column (comparison of methods) differ at 5% significance level by Student's t-test (one-tailed), for dependent samples with 4 degrees of freedom. [2] p-value of the Kolmogorov-Smirnov normality test

(Table 1). This suggests similar experimental precision between these cultivars and sowing dates.

However, it is possible to use plots larger than 1 m^2 to improve experimental precision. This finding is confirmed by the nonlinear decrease in the coefficient of variation [$CV_{(X)}$], with the increase in the planned plot size (X) (Table 2, Figures 2, 3 and 4). There was also a trend of stabilization of $CV_{(X)}$, which demonstrates the importance of using the MMC, LRP and QRP methods to determine the optimal plot size.

Regarding the estimates of the coefficient of determination (R^2), optimal plot size (Xo) and coefficient of variation in the optimal plot size (CV_{Xo}, %) of the methods of modified maximum curvature (MMC), linear response and plateau model (LRP) and quadratic response and plateau model (QRP), the p-value of the Kolmogorov-Smirnov test ranged between 0.53 and 1.00, with a mean of 0.89 (Table 1). The higher the p-value, the greater the adherence of the data to the normal distribution curve. Thus, assuming the significance level of 53%, it can be inferred that the assumption of normality to perform the Student's t-test was met.

The coefficients of determination (R^2) among the five uniformity trials ranged from 0.80 to 0.99, 0.76 to 0.93, and 0.80 to 0.96 for the MMC, LRP and QRP methods, respectively (Table 1, Figures 2, 3 and 4). It should be considered that $0.00 \leq R^2 \leq 1.00$ and its interpretation is that the closer to 1.00 the better the fit of the model to the data. In the comparisons of the methods, regardless of cultivar and sowing date, higher means of R^2 (better fits) were observed in MMC (0.90) and QRP (0.88), which did not differ from each other and were higher than that observed in LRP (0.84). Despite this difference, it is considered that the three methods had R^2 close to the unit ($R^2 \geq 0.84$), giving credibility to the estimates of Xo and CV_{Xo}, calculated from these models.

Table 2 - Planned plot size ($X = X_R \times X_C$), in basic experimental units (BEU), with X_R BEU adjacent in the row and X_C BEU adjacent in the column; number of plots with size of X BEU (n = 108/X); coefficient of variation (in %) between the plots with size of X BEU [$CV_{(X)}$]; and mean of the coefficient of variation (in %) between the plots of X BEU with the same size, but different shapes [$CV_{(X)}$]. Fresh matter productivity data of wheat (*Triticum aestivum* L.) cultivars, obtained in uniformity trials [(1)] conducted on different sowing dates

X_R	X_C	X	n	TBIO Sossego 08/03/2018		TBIO Toruk 08/03/2018		TBIO Audaz 06/07/2019		TBIO Audaz 06/27/2019		TBIO Audaz 07/18/2019	
				$CV_{(X)}$	$CV_{(X)}$ [(2)]	$CV_{(X)}$	$CV_{(X)}$ [(2)]	$CV_{(X)}$	$CV_{(X)}$ [(2)]	$CV_{(X)}$	$CV_{(X)}$ [(2)]	$CV_{(X)}$	$CV_{(X)}$ [(2)]
1	1	1	108	13.73	13.73	18.83	18.83	14.29	14.29	19.59	19.59	19.05	19.05
1	2	2	54	12.30	12.01	16.03	16.61	12.14	12.02	15.59	16.49	12.80	15.18
2	1	2	54	11.71	-	17.20	-	11.89	-	17.39	-	17.57	-
1	3	3	36	10.85	10.92	14.25	15.34	11.13	10.94	12.85	13.64	9.71	12.98
3	1	3	36	10.99	-	16.44	-	10.75	-	14.43	-	16.25	-
2	2	4	27	10.87	10.87	15.20	15.20	10.39	10.39	13.67	13.67	11.89	11.89
1	6	6	18	7.37	9.61	6.66	12.61	7.63	9.05	10.72	11.42	8.58	10.76
2	3	6	18	10.01	-	13.47	-	9.20	-	11.79	-	8.31	-
3	2	6	18	10.45	-	14.41	-	9.58	-	10.66	-	10.89	-
6	1	6	18	10.63	-	15.89	-	9.78	-	12.50	-	15.25	-
3	3	9	12	9.67	9.98	12.42	14.08	8.58	8.55	8.02	9.42	7.41	11.04
9	1	9	12	10.30	-	15.74	-	8.52	-	10.82	-	14.68	-
2	6	12	9	7.12	8.71	5.86	10.05	5.68	7.22	9.68	9.34	8.03	8.79
6	2	12	9	10.31	-	14.25	-	8.75	-	9.01	-	9.54	-
3	6	18	6	7.02	8.95	3.45	11.62	6.20	7.35	4.84	7.35	7.30	8.95
6	3	18	6	9.78	-	12.91	-	8.08	-	6.71	-	5.16	-
9	2	18	6	10.18	-	14.35	-	7.46	-	8.46	-	8.56	-
18	1	18	6	8.80	-	15.77	-	7.65	-	9.41	-	14.78	-
9	3	27	4	9.93	9.93	13.29	13.29	6.74	6.74	6.82	6.82	3.10	3.10
6	6	36	3	7.45	8.25	3.54	9.34	5.42	6.24	2.90	4.95	5.02	6.73
18	2	36	3	9.06	-	15.13	-	7.06	-	6.99	-	8.44	-
9	6	54	2	7.84	8.50	3.54	9.37	2.51	4.81	2.98	3.33	3.60	2.05
18	3	54	2	9.16	-	15.21	-	7.12	-	3.68	-	0.49	-

[(1)] Each uniformity trial with size of 18 m × 6 m (108 m^2) was divided into 108 BEU of 1 m × 1 m (1 m^2), forming a matrix of 18 rows and six columns.
[(2)] $CV_{(X)}$ between the plots with the same size, but different shapes, used in the fitting of the models

Figure 2 - Representation of the optimal plot size (Xo, in m²) and coefficient of variation in the optimal plot size (CV_{Xo}, in %), obtained by the modified maximum curvature (MMC) method, in relation to the fresh matter productivity of wheat (*Triticum aestivum* L.) cultivars, evaluated on different sowing dates

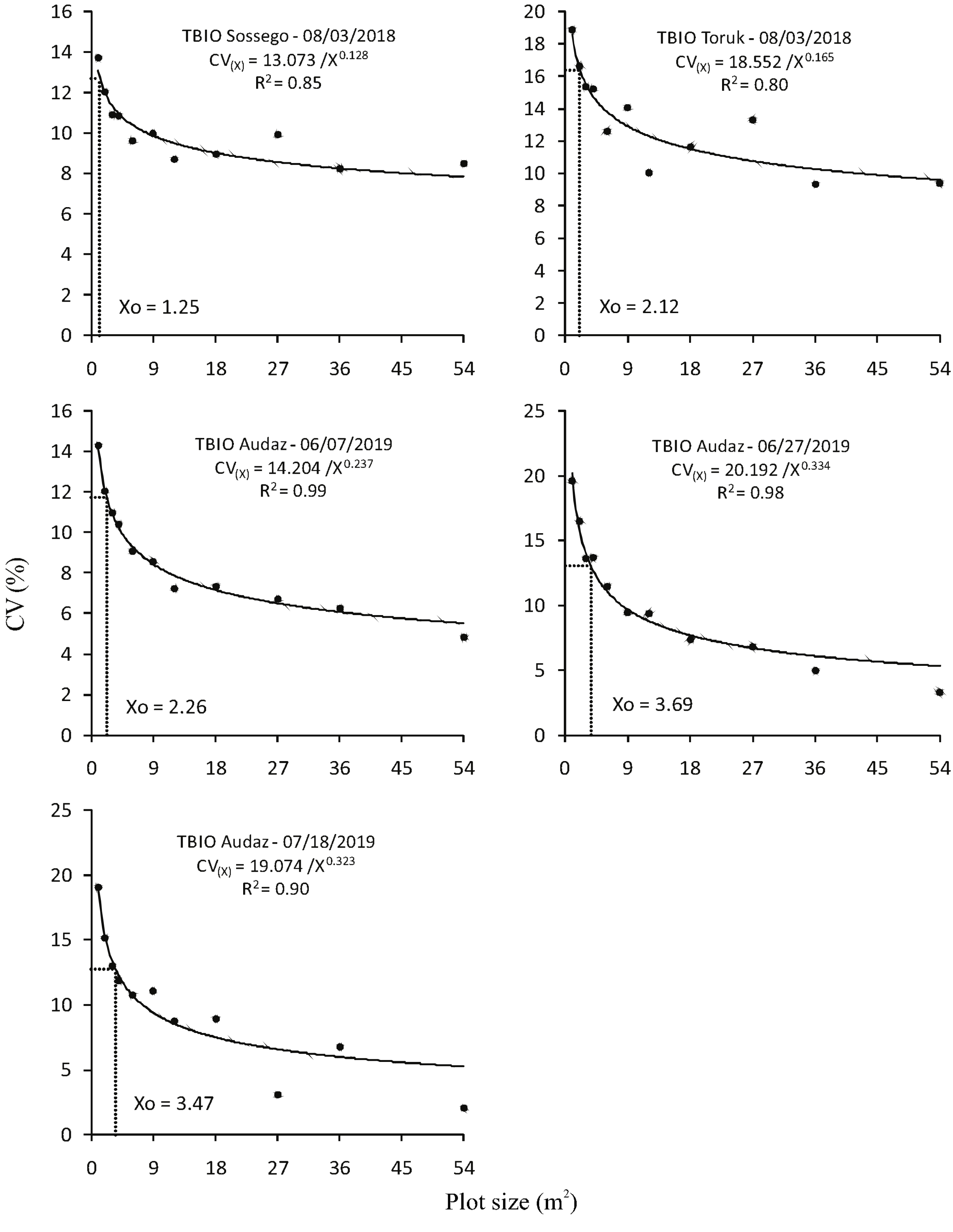


Figure 3 - Representation of the optimal plot size (Xo, in m²) and coefficient of variation in the optimal plot size (CV_{Xo}, in %), obtained by the linear response and plateau model (LRP), in relation to the fresh matter productivity of wheat (*Triticum aestivum* L.) cultivars, evaluated on different sowing dates

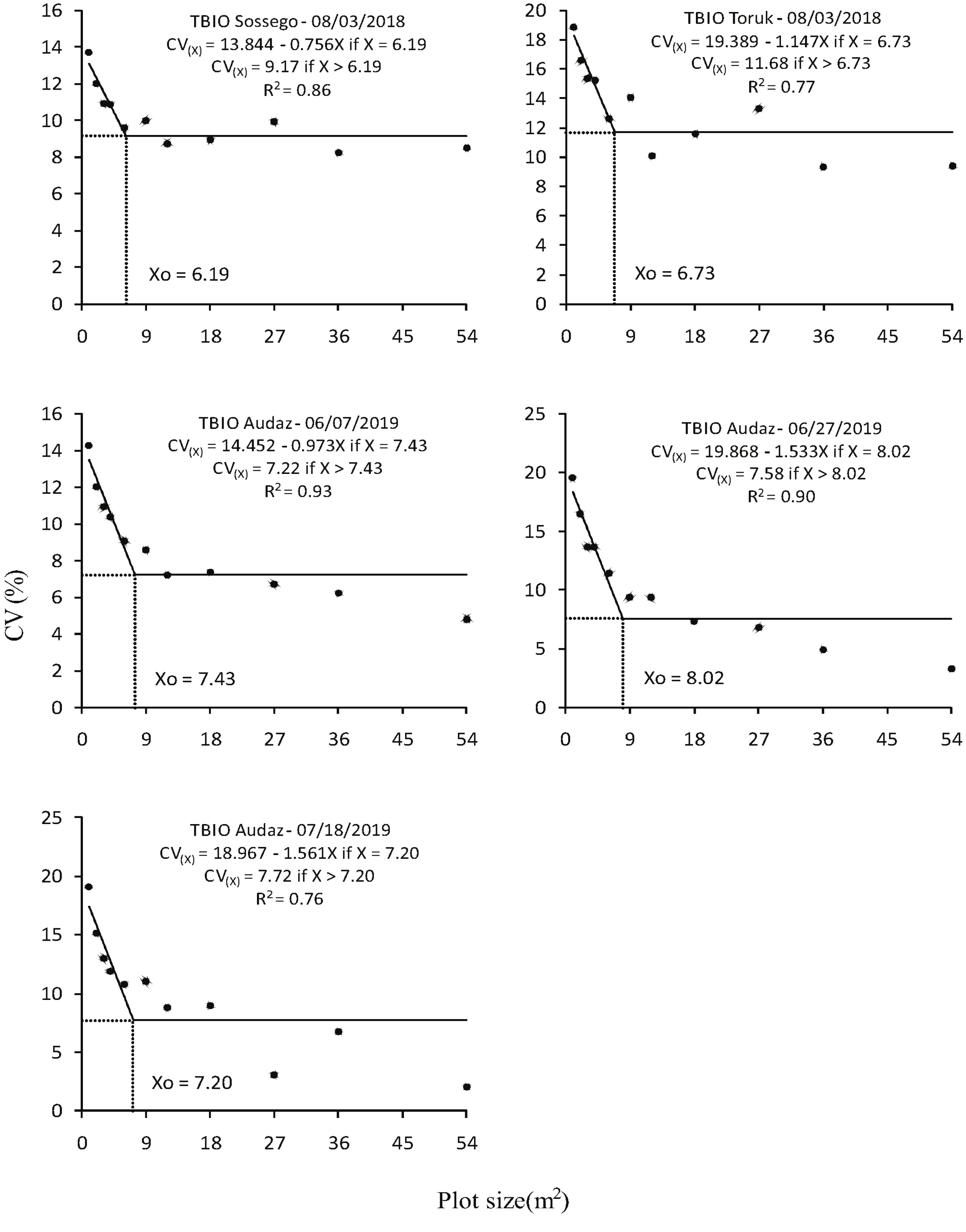
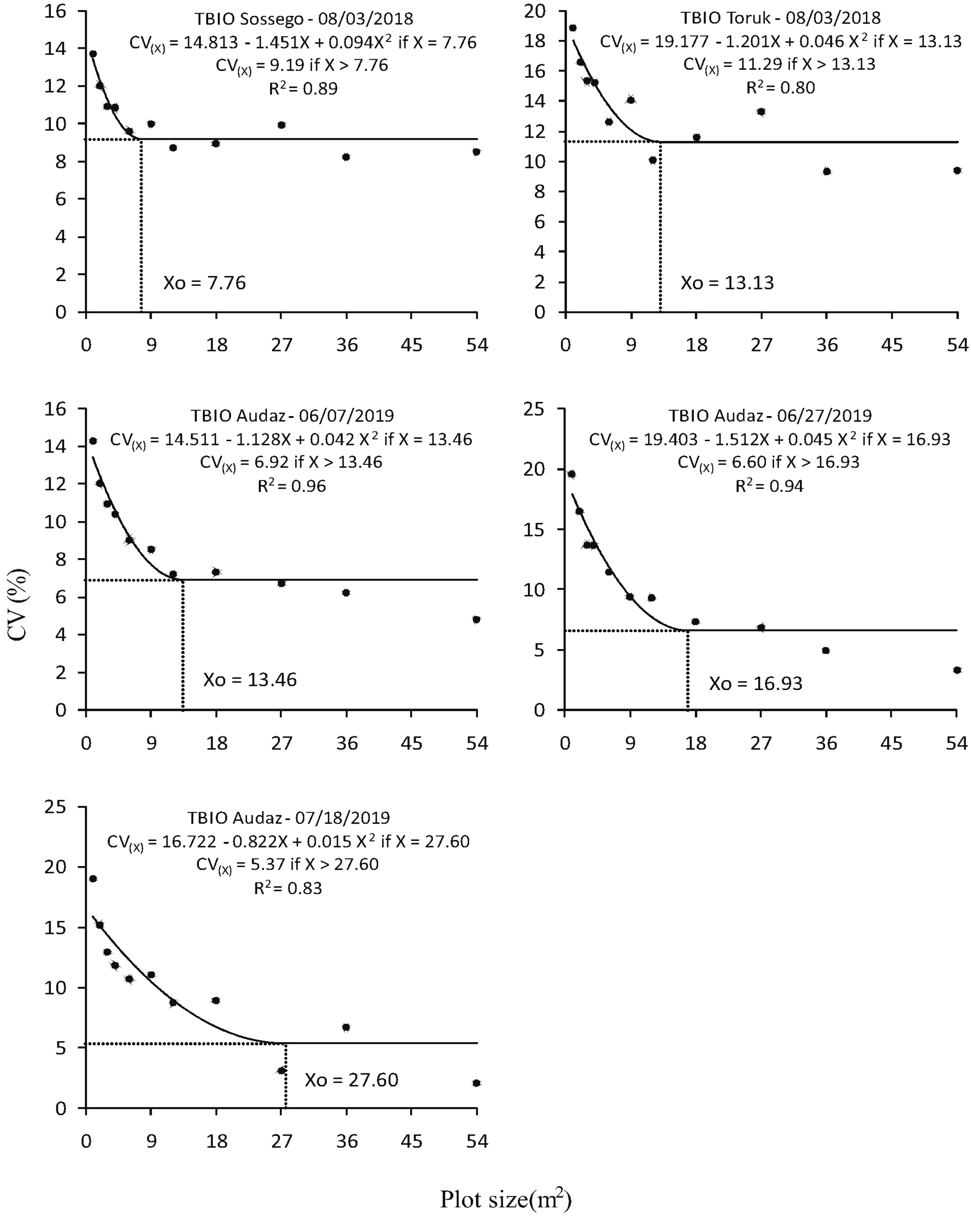


Figure 4 - Representation of the optimal plot size (Xo, in m²) and coefficient of variation in the optimal plot size (CV_{Xo}, in %), obtained by the quadratic response and plateau model (QRP), in relation to the fresh matter productivity of wheat (*Triticum aestivum* L.) cultivars, evaluated on different sowing dates



The optimal plot sizes (Xo), among the five uniformity trials, were higher in the QRP method ($7.76 \leq Xo \leq 27.60$ m^2), intermediate in LRP ($6.19 \leq Xo \leq 8.02$ m^2) and lower in MMC ($1.25 \leq Xo \leq 3.69$ m^2) (Table 1, Figures 2, 3 and 4). The Xo differed among the three methods, being 15.78 m^2 by QRP, 7.11 m^2 by LRP and 2.56 m^2 by MMC. Thus, it can be inferred that the plot size depends on the estimation method. In wheat, the plot sizes determined by Henriques Neto *et al*. (2004) and Lorentz *et al*. (2007) also varied due to the method used in their estimation.

The coefficients of variation in the optimal plot size (CV_{Xo}, in %), among the five uniformity trials, varied between 11.71 and 16.39%; 7.22 and 11.68%; and 5.37 and 11.29%, for the MMC, LRP and QRP methods, respectively (Table 1, Figures 2, 3 and 4). The CV_{Xo} was higher in the MMC method (13.32%) compared to LRP (8.67%) and QRP (7.87%), which did not differ from each other. These results, according to the classification of Pimentel-Gomes (2009), indicate high experimental precision with the use of plot sizes determined by the LRP and QRP methods (CV < 10%) and medium precision with MMC (CV between 10% and 20%).

Among the methods, the means of R^2 were close to the unit, despite the superiority of MMC ($R^2 = 0.90$) and QRP ($R^2 = 0.88$) compared to LRP ($R^2 = 0.84$). The means of Xo were decreasing in the following order: QRP = 15.78 m^2; LRP = 7.11 m^2; and MMC = 2.56 m^2. CV_{Xo} was higher in MMC (13.32%) and there was no difference between LRP (8.67%) and QRP (7.87%). Therefore, although the plot sizes are different between the LRP (7.11 m^2) and QRP (15.78 m^2) methods, they result in similar experimental precision, because their CV_{Xo} values did not differ. This absence of difference is explained by the fact that from a given plot size the gains in precision (decrease in the coefficient of variation) with the increment in plot area are negligible (Figures 2, 3 and 4). Thus, it can be inferred that plots with 7.11 m^2 are suitable for experimental planning. This indication of plots with 7.11 m^2 is supported by practical feasibility in the field and stabilization of precision from this size and can be used as a reference for the planning of experiments with wheat.

Based on different methods, Henriques Neto *et al.* (2004) concluded that to evaluate the grain yield of wheat, under irrigated conditions, in no-tillage and conventional systems, plots with size ranging from 1.6 m^2 to 2.4 m^2 of usable area allow adequate evaluation. Also, from different methods, Lorentz *et al*. (2007) state that the plot size for wheat crop under no-tillage should be between 0.74 m^2 and 4.06 m^2 for number of ears, 0.69 m^2 and 2.64 m^2 for ear weight, and 0.89 m^2 and 6.48 m^2 for grain yield. Therefore, this plot size of 7.11 m^2, required to evaluate the fresh matter productivity of wheat, is relatively larger than those presented by these authors. However, comparisons between the results should be analyzed with caution, due to the different methods used to determine the plot size, environmental differences, different managements of uniformity trials and the variables analyzed.

A pattern similar to that found in the present study, that is, decreasing Xo estimates following order of quadratic response and plateau model, linear response and plateau model and modified maximum curvature, were obtained in crops such as radish (SILVA *et al*., 2012), *Acacia polyphylla* (ALVES *et al*., 2014), sweet potato (GONZÁLEZ *et al*., 2018), cactus pear (GUIMARÃES *et al*., 2019), coffee (MOREIRA *et al*., 2016), millet + slender leaf rattlebox + showy rattlebox (CARGNELUTTI FILHO *et al*., 2021a) and buckwheat (CARGNELUTTI FILHO *et al*., 2021b).

Higher estimates of Xo by QRP compared to LRP were obtained in passion fruit (PEIXOTO; FARIA; MORAIS, 2011). In addition, higher estimates of Xo by LRP compared to MMC were obtained in papaya (BRITO *et al*., 2012), pineapple (LEONARDO *et al*., 2014), cabbage (GUARÇONI *et al*., 2017), cassava (SOUSA *et al*., 2018) and coffee (BRIOSCHI JUNIOR *et al*., 2020). These results agree with those found in the present study.

On the other hand, a pattern different from that observed in the present study has also been observed, that is, similar Xo estimates between the LRP and MMC methods (PADRÓN; LOPES; RENEDO, 2018; RODRÍGUEZ *et al*., 2018) and lower Xo estimates of LRP compared to MMC (CARGNELUTTI FILHO *et al*., 2011; SOUSA *et al*., 2015). Possibly, the lower estimates of Xo with LRP compared to MMC are associated with the occurrence of a possible "false" plateau in LRP (PEIXOTO; FARIA; MORAIS, 2011). According to these authors, there is not always enough amplitude of the planned plot sizes to achieve a response and plateau in segmented models. This may have occurred in the studies which used plot sizes of 1, 2, 3, 4, 6 and 12 BEU (CARGNELUTTI FILHO *et al*., 2011) and 1, 2, 3, 4 and 6 BEU (SOUSA *et al*., 2015).

CONCLUSIONS

The optimal plot size differs between the methods and decreases in the following order: quadratic response and plateau model (15.78 m^2), linear response and plateau model (7.11 m^2) and modified maximum curvature (2.56 m^2). The optimal plot size to evaluate the fresh matter productivity of wheat (*Triticum aestivum* L.) is 7.11 m^2, and the experimental precision stabilizes from this size.

ACKNOWLEDGMENTS

To the National Council for Scientific and Technological Development (CNPq - Processes 304652/2017-2; 159611/2019-9) and the Rio Grande do Sul State Research Support Foundation (FAPERGS) for granting the scholarships. To scholarship-holding students and volunteers for their assistance in data collection.

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